

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



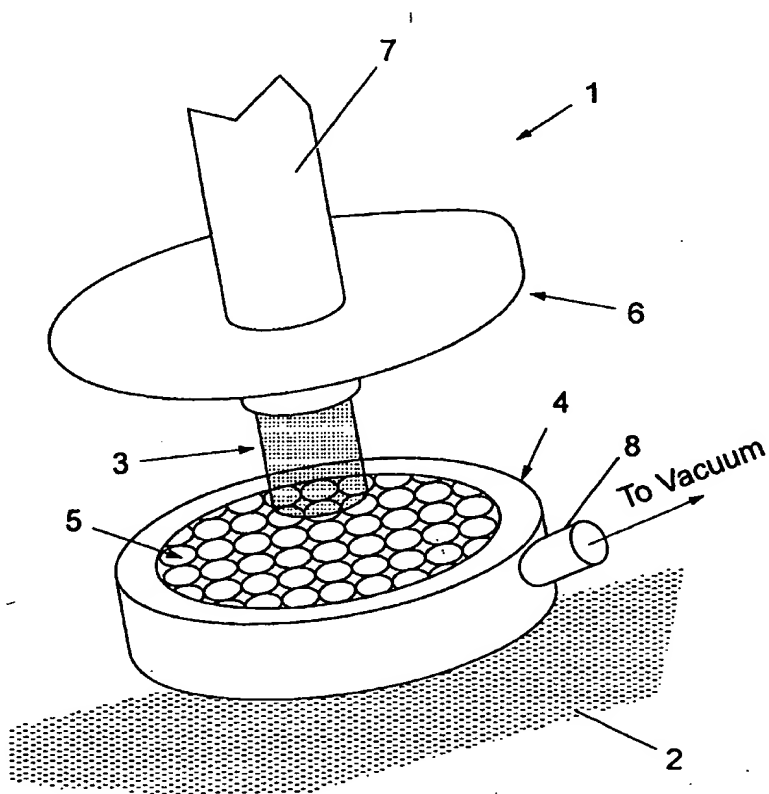
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61B 17/41		(11) International Publication Number: WO 98/52481
A1		(43) International Publication Date: 26 November 1998 (26.11.98)
(21) International Application Number: PCT/GB98/01523 (22) International Filing Date: 26 May 1998 (26.05.98) (30) Priority Data: 9710562.1 23 May 1997 (23.05.97) GB (71) Applicant (for all designated States except US): MEDICAL LASER TECHNOLOGIES LIMITED [GB/GB]; Unit 4, Belleknowes Industrial Estate, Inverkeithing, Fife KY11 1HY (GB). (72) Inventor; and (75) Inventor/Applicant (for US only): COLLES, Michael, John [GB/GB]; Boglesknowe, Hartree by Biggar, Lanarkshire ML12 6JJ (GB). (74) Agent: MURGITROYD & COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: APPARATUS AND METHOD FOR DELIVERY OF LIGHT TO SKIN

(57) Abstract

Improvements to a system for the process of hair removal which employs a collimated laser beam delivered to a target. These improvements include a reflector for reflecting back light scattered from the surface and improving light coupling into the tissue, use of an array of micro lenses for focusing the incident beam, and an annular ring to thin the epidermis and upper dermis to reduce blood volume in the illuminated area, and increase flux density at significant depths.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

1
2 Apparatus and method for delivery of light to skin

3
4 This invention relates to light delivery and in
5 particular to a apparatus and method for delivery of a
6 beam of light to a target area beneath the surface of
7 the skin.

8
9 Most particularly this invention relates to an
10 apparatus and method designed to improve the delivery
11 of laser or other light to targets underneath the skin
12 surface especially, but not solely, to assist in
13 optical hair removal. That is, this invention relates
14 to the use of optical based techniques in dermatology
15 for the removal of unwanted stains, pigment, marks,
16 hairs, or other sub-surface features.

17
18 Lasers and, in some cases, other light sources have
19 found increasing use in dermatology for the treatment
20 or removal of sub-surface lesions. These techniques
21 have largely been based on the concepts of selective
22 photothermolysis. This implies that the laser
23 wavelength is chosen to match a characteristic
24 absorption associated with the target but not with the
25 surrounding tissue. Thus, absorption of the laser

1 light and the subsequent heating is largely restricted
2 to that target. In addition, the process also involves
3 choosing the duration of the laser pulse to maximise
4 the temperature of the target before significant
5 conduction to the surrounding tissue can take place.
6 For example, a 30 nanosecond pulse from a Nd:YAG laser
7 at $1.06\mu\text{m}$ is strongly and selectively absorbed in the
8 blue-black pigments of common tattoos. Since the
9 tattoo pigments accumulate in granules of micron size,
10 such a short pulse is almost wholly used to heat and
11 fragment the granule before significant heating of the
12 surroundings takes place.

13
14 More recently techniques have been described which
15 relate to the removal of unwanted hair using lasers.
16 In one approach a Nd:YAG laser similar to the one
17 mentioned above is used. Since there is little or no
18 natural selective absorption at this wavelength, an
19 external chromophore must first be applied and
20 persuaded to migrate down the hair shaft to the base to
21 provide an appropriate target.

22
23 In an alternative approach a ruby laser at 0.694nm is
24 used. In this approach the melanin content of the hair
25 shaft provides the selectively absorbing chromophore.

26
27 The ruby laser was introduced many years ago for
28 removal of tattoos. For tattoo removal the laser
29 output was "Q-Switched" - that is, the energy was
30 compressed to a pulse of only a few 10 's of
31 nanoseconds. Such a pulse, whilst ideal for tattoo
32 granule fragmentation, is neither necessary nor
33 desirable for the more thermal process of hair removal.

34
35 For hair removal, the ruby laser is operated in its so-
36 called "normal mode" wherein the pulse duration is

1 extended to about 1 millisecond. The real target is
2 not the hair itself. Following the selective
3 absorption of the laser light along the buried hair
4 shaft and the heating of the latter, the overall
5 process relies on the conduction of heat from the shaft
6 to surrounding tissue, in particular to two zones, the
7 first near the shaft base (papilla); and the second
8 approximately a third of the way down the shaft, known
9 as the bulge. Direct absorption into these zones is
10 possible, and can contribute to their heating since
11 they also contain an enhanced level of melanin. These
12 zones are believed to contain the cells responsible for
13 hair growth, and damage to them via this process of
14 laser heating should lead to permanent hair removal or
15 at least substantially delayed regrowth.

16
17 A simple approach is to apply light with the required
18 level of energy density to an area of skin. The level
19 is chosen to give sufficient heating to destroy the
20 target zones whilst leaving the surrounding tissue
21 undamaged. In practice this required level lies
22 between 10 and 50 J/cm².

23
24 Various techniques have been used or proposed to assist
25 in improving the efficiency of the process. These
26 techniques include precooling of the area, cooling
27 during the process, selective cooling of the epidermis
28 using millisecond cryogen spray, use of optical
29 transmitting gels to improve coupling into the tissue,
30 convex shaped applicators, and devices to draw folds of
31 skin which may receive radiation from either side.

32
33 Whereas there may be both advantages and disadvantages
34 to varying degrees in all of these approaches, it is
35 manifest that there is a need for a beam delivery
36 system that addresses the problems of sub-surface

1 targeting from both an optical and a biological
2 viewpoint.

3
4 According to a first aspect of the present invention
5 there is provided an apparatus for delivery of a beam
6 of light to a target area beneath the surface of the
7 skin comprising means to deliver a collimated light
8 beam, and light delivery means to increase the light
9 energy density at said target area while minimising the
10 light energy density at the surface of the skin.

11
12 Preferably said means to improve delivery comprises
13 means to improve effective light coupling into tissue.
14 Said means to improve effective light coupling may
15 comprise recovery means to recover light reflected on
16 incidence with the skin.

17
18 Said recovery means may comprise a reflective surface.

19
20 Preferably the apparatus comprises means to thin the
21 skin above the target area. Said means may stretch the
22 skin.

23
24 Preferably the apparatus comprises means to reduce
25 local blood flow in the target area.

26
27 Preferably the means to stretch the skin acts also to
28 reduce the local blood flow.

29
30 Preferably the apparatus comprises means to subject the
31 area adjacent the target area to vacuum suction.

32
33 Said means may comprise a member adapted to be sealed
34 to the skin and to subject the area of skin surrounding
35 the target area to a vacuum.

36

1 Preferably said member has an annular channel. Said
2 channel may be ring shaped or oval.
3 Preferably said channel is adapted to be positioned
4 with the channel opening in contact with the skin.
5
6 Preferably the apparatus comprises means to increase
7 light flux density at the depth of the target. Said
8 means may redistribute an incident collimated beam
9 prior to its incidence with the skin.
10
11 Said redistribution means may comprise an array of
12 lenses. Preferably said lenses are of short focal
13 length. Preferably said array is selected to increase
14 the flux density at a nominated depth.
15
16 Preferably the apparatus comprises recovery means to
17 recover light reflected on incidence with the skin;
18 means to thin the skin above the target; and means to
19 increase light flux at the depth of the target.
20
21 Preferably the light beam is a laser light beam.
22
23 The apparatus may further include known techniques such
24 as tissue precooling and/or selective cooling of the
25 epidermis and/or use of optical transmitting gels
26 and/or convex shaped applicators and/or devices to draw
27 folds of skin which may receive radiation from either
28 side and/or other features already known.
29
30 According to a second aspect of the present invention
31 there is provided a method for delivery of a beam of
32 light to a target area beneath the surface of the skin
33 comprising the step of using an apparatus according to
34 the first aspect of the invention.
35
36 According to a further aspect of the present invention

1 there is provided a method for delivery of a beam of
2 light to a target area beneath the surface of the skin
3 comprising the steps of directing a collimated light
4 beam onto the surface of the skin, and using a light
5 delivery means to increase the light energy density at
6 said target area while minimising the light energy
7 density at the surface of the skin.

8
9 Embodiments of the present invention will now be
10 described by way of example only with reference to the
11 accompanying drawings in which:

12
13 Figure 1 shows a apparatus in accordance with an
14 aspect of the present invention.

15
16 Figures 2a and 2b illustrate the effect on fluence
17 at the skin surface and at a given depth beneath
18 the surface, of increasing the area of surface
19 illumination of the skin;

20
21 Figures 2c and 2d also illustrate the effect on
22 fluence at the skin surface and at a given depth
23 beneath the surface, of increasing the area of
24 surface illumination;

25
26 Figure 2e is a graphical representation of the
27 rate of increase of the effective fluence at depth
28 with increase of surface beam diameter;

29
30 Figures 3a and 3b show a beam focusing
31 arrangements in accordance with an aspect of the
32 present invention;

33
34 Figure 4 illustrates means for recapturing
35 reflected light in accordance with an aspect of
36 the present invention; and

1 Figure 5 shows an annular ring in accordance with
2 an aspect of the present invention.

3
4 Referring to the drawings, this apparatus, generally
5 designated 1 is designed to provide a combination of
6 both optical and mechanical means of improvement of the
7 sub-surface flux density of a beam delivered by a beam
8 delivery system to the target areas. Although this
9 apparatus has its origins in improvements related to
10 beam delivery for hair removal, other optical processes
11 requiring selective sub-surface damage may benefit.

12
13 A beam delivery system normally comprises a light
14 source and means for its delivery to a target area. A
15 first improvement to this system is the provision of a
16 sealed annular ring 4 as shown in Figure 5. This
17 annular ring is placed adjacent the tissue surface 2
18 above the target. The region of surface skin in the
19 annulus is subject to a vacuum by connection of a
20 vacuum pump to vacuum outlet 8 and is thus drawn
21 upwards to form raised areas 11. In one dimension this
22 is similar to proposals for obtaining a fold of tissue
23 to allow transillumination. However the instant
24 configuration takes advantage of the fact that dermal
25 blood is taken towards the region 11 under vacuum in
26 the direction of arrows 10 and thus away from the
27 central circular core area 12.

28
29 Although the ruby laser wavelength corresponds to a
30 minimum in the absorption spectrum of blood, residual
31 absorption of blood remains a competing unwanted factor
32 in the utilisation of the laser light. Thus reduction
33 of local blood volume due to adjacent vacuum suction
34 provides an important advantage.

35
36 A second and more significant effect is that the

1 drawing up into the annulus of a small amount of tissue
2 13 effectively stretches the skin 2 throughout the
3 circular core 12. Even mild stretching of around 10%
4 of the diameter - 2mm in Figure 5 where the central
5 area has a diameter of 20mm - translates to a thinning
6 of the epidermis and upper dermis of 20%. Since the
7 reduction in light flux with depth into the skin is
8 exponential this thinning provides an increase in flux
9 density of as much as 80% at a depth of 3mm
10 corresponding to the depth of the papilla. This
11 effect, in conjunction with the reduction of the local
12 blood volume, reduces the required incident flux
13 density by a significant factor. These effects also
14 improve the selectivity of the process.

15
16 This aspect of the invention is thus directed
17 principally at providing a physical means of reducing
18 beneficially both the blood content of the tissue
19 immediately below the exposed area, and the thickness
20 through which light must penetrate to reach structures
21 at depths of several millimetres.

22
23 Both these effects, that is the biological and the
24 physical, combine to improve the fraction of light
25 fluence (energy per unit area) at the required depth
26 for a given fluence at the surface.

27
28 Usually if the target structures are at some
29 significant depth into tissue, a problem arises in
30 trying to balance the need for a minimum fluence at
31 depth required to effect the necessary damage, whilst
32 sparing structures nearer the surface that normally see
33 a significantly higher fluence. This aspect of the
34 invention acts directly to improve this situation and
35 thus helps in sparing surface tissue and components.

36

1 A handpiece incorporating such a ring 4 has its most
2 immediate application in a process such as hair removal
3 where selective damage to the follicles 2-4mm deep is
4 required. Other applications, for example the
5 visualisation of dermal blood vessel anatomy for
6 diagnostic purposes would also benefit.

7
8 The influence of light scattering in tissue is to
9 substantially increase the volume of tissue
10 experiencing some of the light compared with the
11 initially exposed area. The larger the initial area,
12 the less this affects the fluence at a given depth
13 other than near the perimeter of the area.

14
15 This phenomenon is best understood by reference to
16 Figures 2a and 2b.

17
18 In Figure 2a the spread of the energy present in the
19 beam, that is, the expansion of the beam due to
20 scattering, is indicated approximately by following a
21 line 30 representing the average direction of scattered
22 photons. The energy incident on the surface is within
23 an area 20 of 1mm^2 , but at a depth of 3mm 50% of the
24 incident energy can be found within a much larger area
25 21 of 1cm^2 . Thus the surface fluence is reduced by
26 about a factor of 200. (This assumes that no
27 absorption takes place.)

28
29 If a second area 22, adjacent to the first area 20 and
30 also of 1mm^2 , is illuminated with equal energy, then
31 the fluence (energy density) on the surface remains
32 constant. It can be seen from Figure 2b that at depth
33 the energy from the second source in area 23 very
34 largely overlaps that of the first source in area 21.
35 Thus the fluence at depth has almost doubled for no
36 change in surface fluence.

1 Figures 2c and 2d show the same effect but with sample
2 fluences typical of laser hair removal.

3
4 This process continues with the fraction of the surface
5 fluence effective at depth increasing with size of
6 illuminated area. The rate of increase slows to give a
7 constant fraction when the illuminated area of the
8 surface is several cm^2 . This function is sketched in
9 Figure 2e, in which line 40 shows the fluence at 3mm
10 depth (in J/cm^2) plotted against the beam diameter at
11 the surface (in mm).

12
13 The numbers used in this example are illustrative only
14 but are close to those encountered in skin. In the
15 case of hair removal, a target is approximately 3 mm
16 deep and therefore a certain level of fluence will be
17 required at that depth to achieve the required
18 therapeutic effect.

19
20 This therapeutic fluence is determined by the
21 absorption of light from lasers such as ruby and
22 alexandrite into the melanin within and around the
23 follicle. The epidermis and upper dermis, however,
24 contain the same absorbing chromophore as that present
25 in the target. Since it is desirable to spare the
26 epidermis and upper dermis from damage, and these occur
27 nearer the surface, it is clear that any means by which
28 the ratio of fluence at a depth compared with surface
29 fluence can be increased offers an improvement in
30 efficacy and safety.

31
32 An approach taught in current practice is to use large
33 areas of illumination. However this novel approach,
34 and the second aspect of the invention, is to use a
35 lens 15 to sharply focus the incident beam 3 to a point
36 16 around 3 mm below the surface 2 as shown in Figure

1 3a. Although there are many scattering events as light
2 moves through the tissue, with the consequences
3 outlined above, each event scatters light in a
4 predominantly forward direction. A sharply focused
5 beam therefore offers some counteraction to the spread
6 induced by scattering.

7
8 Unfortunately, to focus the whole beam from a pulsed
9 laser such as ruby or alexandrite presents a serious
10 safety hazard; the slightest incorrect positioning of
11 the focal point would substantially increase the
12 coherent fluence at the surface and lead to severe
13 damage.

14
15 Figure 3b shows an arrangement which overcomes this
16 disadvantage by passing the large area collimated beam
17 3 through an array 5 of small micro lenses 5a. These
18 lenses are of short focal length. The focusing
19 function of this array 5 is estimated to double the
20 sub-surface flux at point 17. There is insufficient
21 energy falling within the acceptance area of an
22 individual lens 5a to present a safety hazard.

23
24 A third aspect of the invention addresses the issue of
25 light coupling into tissue. As mentioned above, the
26 use of a gel has been suggested as a way of improving
27 light coupling. Since the tissue surface is
28 microscopically uneven, applying a gel - and thus
29 essentially smoothing the surface profile to one of
30 near normal incidence to the beam - would indeed help
31 to reduce the reflection losses associated with the
32 refractive index difference between tissue and air.
33 Unfortunately this technique does not really address
34 the reason for the 'apparent' high reflectivity of
35 tissue.

36

1 The greater portion of the apparent reflected light is
2 caused not by index mismatch but rather by transmission
3 into the tissue followed by scattering into a backward
4 direction and finally re-emergence.

5
6 Although each scattering event is predominantly in the
7 forward direction, there are, on average, some 200 such
8 events per mm penetration. As described earlier some
9 50% of the incident energy contributes to the fluence
10 at depth whilst the remaining 50% is scattered in all
11 the other directions. A half of this, that is 25% of
12 the total, actually finds its way out of the tissue,
13 contributing to the apparent reflected energy. This
14 figure of 25% is approximate and depends on the nature
15 of the tissue. In skin it can also vary between
16 individuals and on sites on the same individual.
17 However, the figure usually is between 20% and 40%.

18
19 This aspect of the invention seeks to provide means of
20 capturing this effectively reflected light by using a
21 mirror surface 6 around the handpiece 7 and thus
22 returning the light to the tissue surface 2 once more.
23 This is shown in Figure 4. The area of surface that is
24 the source of this back scattered light is larger than
25 the original illuminated area, and the emerging ray
26 directions 18 are spread widely. Under these
27 circumstances, only limited focusing of the light to be
28 returned to the tissue is possible. This is achieved
29 using a mirror surface 6 of a parabolic form. A
30 simpler hemispherical shape or a conical section are
31 alternatives which give adequate advantage.
32 Irrespective of shape, the action of returning the back
33 scattered light to the tissue surface effectively
34 provides an increase in overall coupling, and thus a
35 reduction in the applied energy required to reach a
36 therapeutic level. This reduction is estimated to be

1 around 20% and therefore an initial requirement of, for
2 example, a fluence of 20 J/cm² at the surface 2 would be
3 reduced to around 16 J/cm².

4
5 In summary, the embodiment shown in Figure 1 shows an
6 apparatus 1 incorporating a combination of the
7 improvements outlined above. This apparatus 1 includes
8 means 4 for drawing up an annulus of tissue, thereby
9 both stretching and thinning the central zone above a
10 target area. This central zone is illuminated with a
11 collimated laser beam 3 passing through an array of
12 micro lenses 5. Typically these lenses may be 1mm in
13 diameter and have a focal length of around 10mm. The
14 delivery handpiece 7 is provided with a means 6 of
15 reflecting back any scattered light returning from the
16 tissue surface.

17
18 This embodiment incorporates all the improvements
19 described. Each individual improvement, that is the
20 annular ring 4, the array of micro lenses 5 and the
21 reflector 6 may be separately applied in other simpler
22 embodiments without detracting from their individual
23 novelty.

24
25 Each individual improvement may also be combined with
26 other established methods such as tissue precooling.
27 Other techniques, for example, for stretching the skin,
28 would be included in the general principles outlined
29 here.

30
31 The embodiment described above offers significant
32 advantages to the process of hair removal with lasers
33 or other optical means. Specifically these include a
34 change in the distribution of light to increase the
35 flux density at significant depths of, for example,
36 between 1 and 3 millimetres, a reduction in the blood

1 volume in the illuminated area and an increase in the
2 effective light flux coupled to the skin. Thus
3 selectivity is improved and the optical energy from the
4 laser or other source is reduced. The embodiment shows
5 specific means for achieving these advantages.

6

7

8 Improvements and modifications may be made to the above
9 without departing from the scope of the invention.

1 CLAIMS

- 2 1. An apparatus for delivery of a beam of light to a
3 target area beneath the surface of the skin
4 comprising:
5
6 a collimated light beam source; and
7
8 light delivery means to increase the light energy
9 density at said target area while minimising the
10 light energy density at the surface of the skin.
11
- 12 2. An apparatus as claimed in Claim 1 wherein said
13 delivery means comprises a reflective surface
14 adapted to recover light reflected away from the
15 skin on incidence with the skin and to redirect
16 said reflected light towards the skin.
17
- 18 3. An apparatus as claimed in any preceding claim
19 wherein said delivery means comprises means to
20 stretch the skin above the target area.
21
- 22 4. An apparatus as claimed in Claim 3 wherein said
23 delivery means comprises means to subject an area
24 of skin adjacent to the skin above the target area
25 to vacuum suction.
26
- 27 5. An apparatus as claimed in Claim 4 wherein said
28 delivery means comprises an annular channel member
29 adapted to be sealed to the skin.
30
- 31 6. An apparatus as claimed in Claim 5 wherein said
32 channel is ring shaped or oval or of other shape.
33
- 34 7. An apparatus as claimed in Claim 5 or Claim 6
35 wherein said channel is adapted to be positioned
36 with the channel opening in contact with the skin.

- 1 8. An apparatus as claimed in any preceding claim
2 wherein said delivery means comprises means to
3 redistribute an incident collimated beam prior to
4 its incidence with the skin.
5
- 6 9. An apparatus as claimed in Claim 8 wherein said
7 redistribution means comprises an array of lenses.
8
- 9 10. An apparatus as claimed in Claim 9 wherein said
10 lenses are of short focal length.
11
- 12 11. An apparatus as claimed in Claim 9 or Claim 10
13 wherein said array is adapted to increase the flux
14 density at a predetermined depth.
15
- 16 12. An apparatus as claimed in any preceding claim
17 wherein the light beam is a laser light beam.
18
- 19 13. An apparatus as claimed in any preceding claim
20 further comprising means for precooling the tissue
21 and/or means for selective cooling of the
22 epidermis and/or devices to draw folds of skin
23 which may receive radiation from either side.
24
- 25 14. A method for delivery of a beam of light to a
26 target area beneath the surface of the skin
27 comprising the step of using an apparatus
28 according to any preceding claim.
29
- 30 15. A method for delivery of a beam of light to a
31 target area beneath the surface of the skin
32 comprising the steps of:
33
34 directing a collimated light beam onto the surface
35 of the skin; and
36

1 using a light delivery means to increase the light
2 energy density at said target area while
3 minimising the light energy density at the surface
4 of the skin.

5
6 16. A method as claimed in Claim 15 wherein a
7 reflective surface is used to recover light
8 reflected away from the skin on incidence with the
9 skin and to redirect said reflected light towards
10 the skin.

11
12 17. A method as claimed in any of Claims 15 to 16
13 wherein the skin is stretched above the target
14 area.

15
16 18. A method as claimed in Claim 17 wherein an area of
17 skin adjacent to the skin above the target area is
18 subjected to vacuum suction.

19
20 19. A method as claimed in Claim 18 wherein a vacuum
21 member comprising an inverted annular channel is
22 placed around the target area and the vacuum
23 member is evacuated to draw the skin into the
24 annular channel.

25
26 20. A method as claimed in any one of Claims 15 to 19
27 wherein said collimated light beam is passed
28 through an array of coplanar lenses positioned
29 above the skin surface.

30
31 21. A method as claimed in Claim 20 wherein said
32 lenses are microlenses of short focal length.

33
34 22. A method as claimed in Claim 20 or Claim 21
35 wherein said array is adapted to increase the flux
36 density at a predetermined depth below the skin

- 1 surface.
2
3 23. A method as claimed in Claim 22 wherein said
4 predetermined depth is between 1 and 5 mm,
5 preferably between 2 and 4 mm.
6
7 24. A method as claimed in any one of Claims 15 to 23
8 wherein the light beam is a laser light beam.
9
10 25. A method as claimed in any preceding claim further
11 comprising the steps of precooling the tissue
12 and/or selective cooling of the epidermis and/or
13 use of optical transmitting gels and/or use of
14 convex shaped applicators and/or use of devices to
15 draw folds of skin which may receive radiation
16 from either side.
17
18

1 / 5

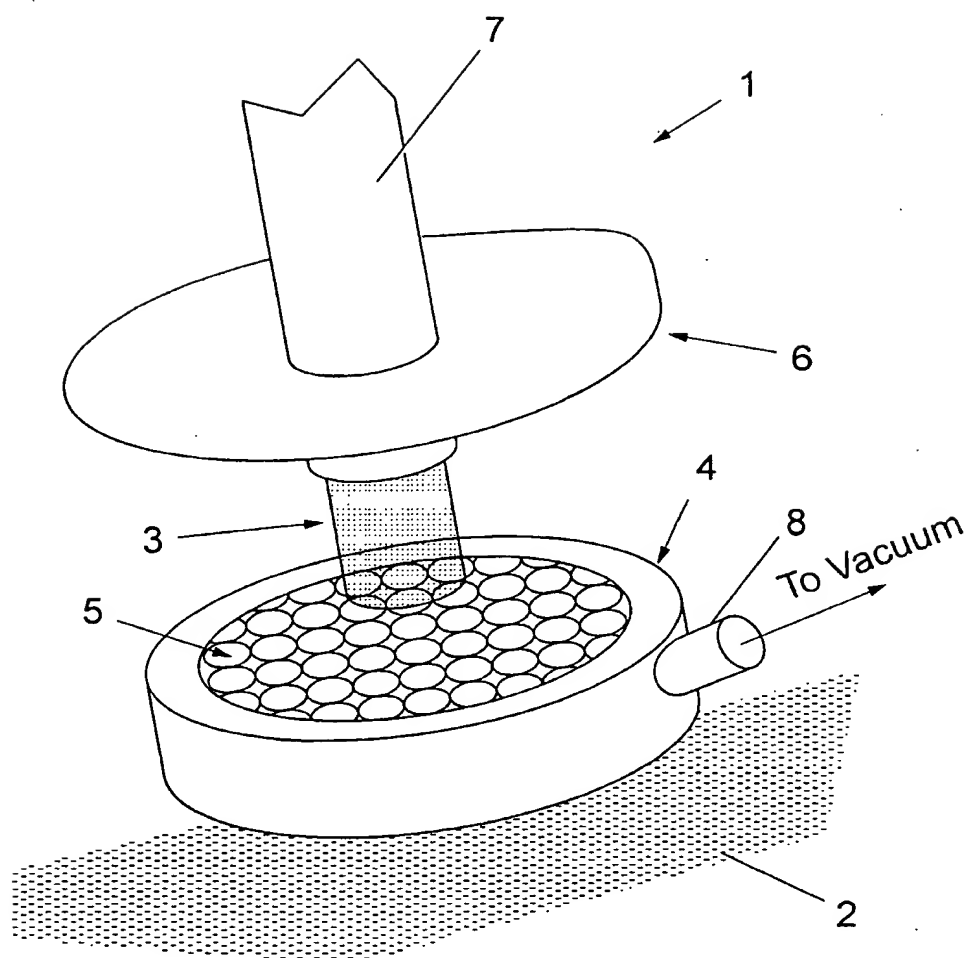


Fig. 1

2 / 5

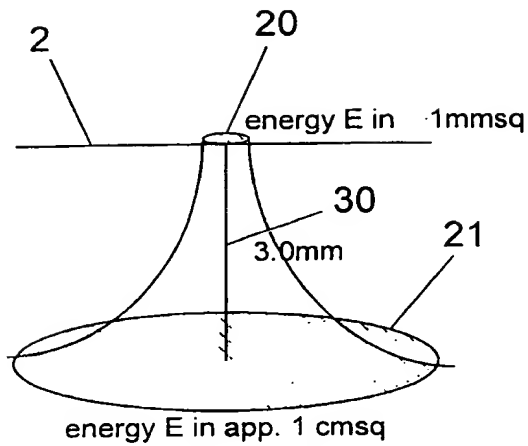


Fig. 2a

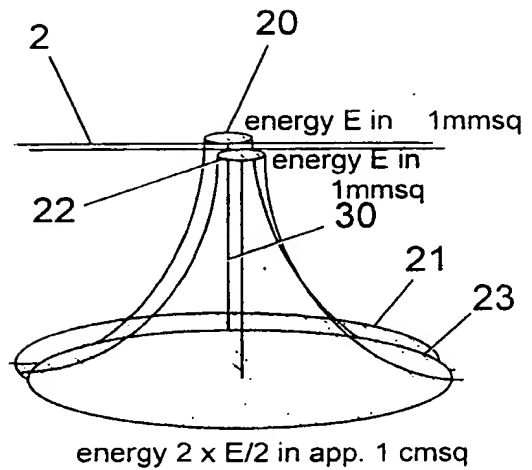


Fig. 2b

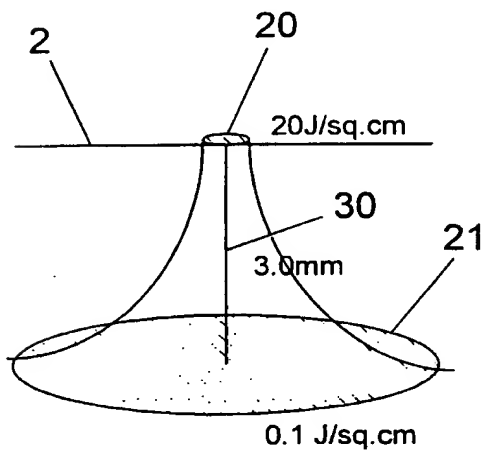


Fig. 2c

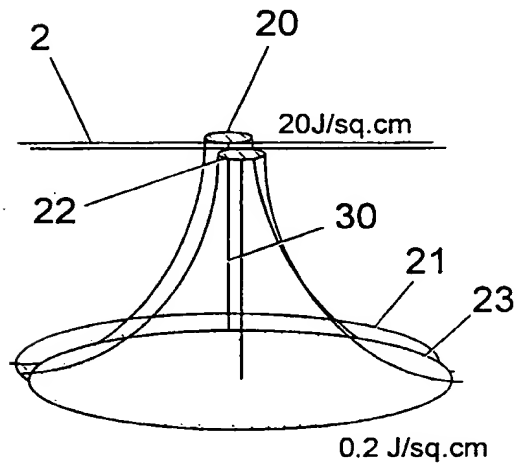


Fig. 2d

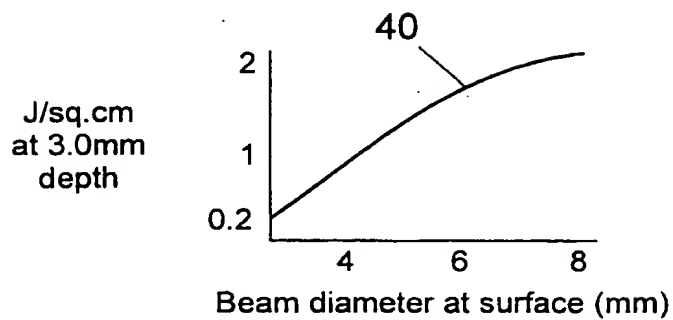


Fig. 2e

3 / 5

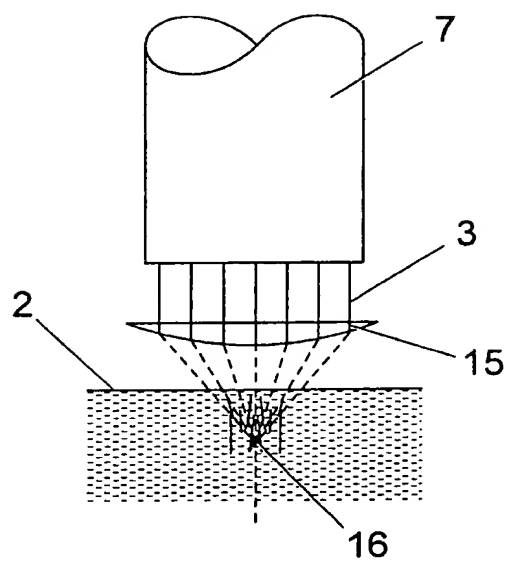


Fig. 3a

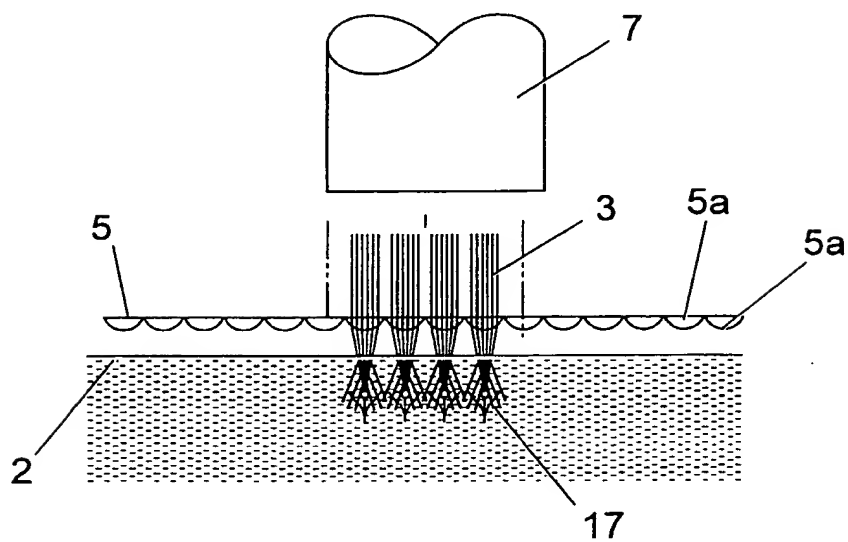


Fig. 3b

4 / 5

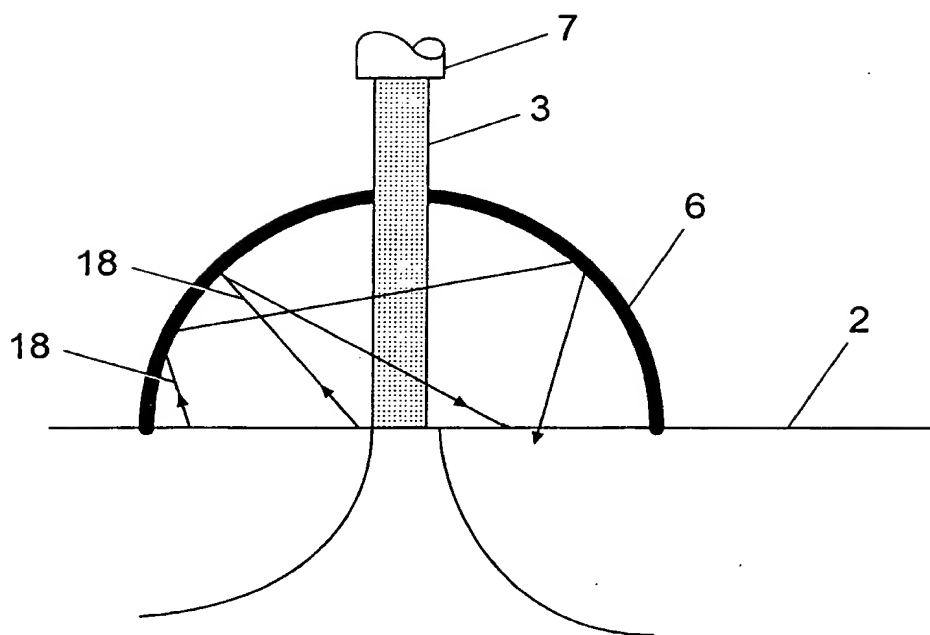
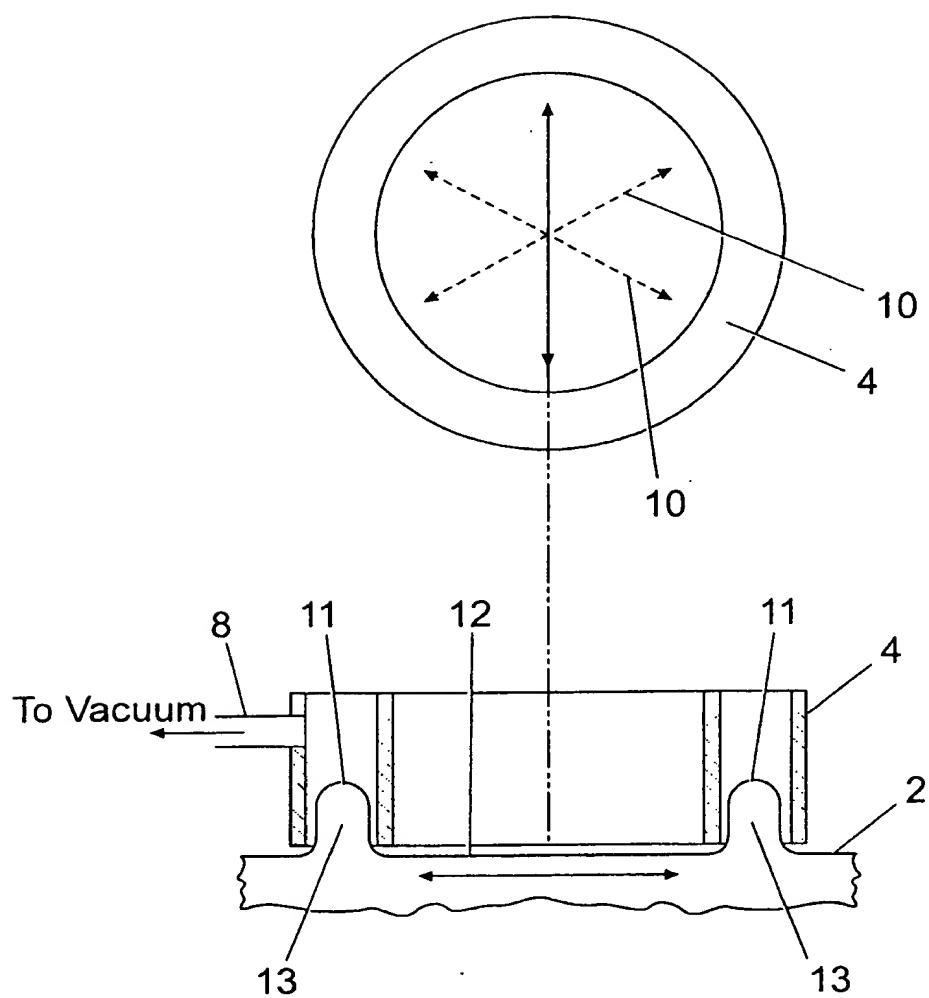


Fig. 4

5 / 5

*Fig. 5*

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01523

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61B17/41

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61B A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 595 568 A (ANDERSON) 21 January 1997 see abstract see column 4, line 50 - column 5, line 32 see column 4, line 50 - column 5, line 32 see column 5, line 63 - column 6, line 21 see column 6, line 42 - line 56 ---	1-3, 12, 13
X	US 5 546 214 A (BLACK) 13 August 1996 see abstract ---	1, 2
X	WO 84 02644 A (WEISSMAN) 19 July 1984 see abstract ---	1
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

30 July 1998

Date of mailing of the international search report

05.08.98

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Taccoen, J-F

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01523

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5 735 844 A (ANDERSON) 7 April 1998 see abstract; figures 2A,2B,3B see column 2, line 6 - line 47 see column 5, line 21 - column 6, line 36 see column 14, line 5 - line 67 ---	1-13
P,X	US 5 653 706 A (ZAVISLAN) 5 August 1997 see abstract see column 1, line 31 - line 52 -----	1-3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 98/01523

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 14-25
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(4)
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 98/01523

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5595568 A	21-01-1997	CA 2210720 A CN 1172420 A EP 0806913 A WO 9623447 A US 5735844 A	08-08-1996 04-02-1998 19-11-1997 08-08-1996 07-04-1998
US 5546214 A	13-08-1996	NONE	
WO 8402644 A	19-07-1984	EP 0134206 A	20-03-1985
US 5735844 A	07-04-1998	US 5595568 A CA 2210720 A CN 1172420 A EP 0806913 A WO 9623447 A	21-01-1997 08-08-1996 04-02-1998 19-11-1997 08-08-1996
US 5653706 A	05-08-1997	AU 7401094 A EP 0710136 A JP 9501334 T WO 9503089 A	20-02-1995 08-05-1996 10-02-1997 02-02-1995